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ABSTRACT

The technology behind digital multimedia is explained, and some of its specific uses and advantages are outlined. Multimedia is a catch-all term for various technologies. As the reputation for instructional effectiveness of multimedia has grown, the demand for a digital form of multimedia has increased, particularly as the limitations of analog multimedia become more apparent. Essentially, digital video interactive (DVI) forms transform and compress analog information into digital information representing sound and video. The advantages have been accepted for some time, especially in terms of being able to communicate over computers. The technical aspects of compression to digitize video and other facets of production are sketched. Optical data disks (CD-ROM) are the perfect vehicle for distributing applications and DVI files because of their large storage capacity and the fact that files can be played back at a convenient rate. The International Business Machines (IBM) ActionMedia II adapter is used to decompress and play back DVI video and audio. Other options with this adapted and related software are reviewed. With this technology it is possible to deliver useful and instructive applications of digital video on a CD-ROM, for a combination of quality, affordability, and portability. (SLD)

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An IAT Technology Primer

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Digital Multimedia

Edwin J. Pinheiro and Diana Oblinger, Ph.D.

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Digital Multimedia

Edwin J. Pinheiro and Diana Oblinger, Ph.D.

Overview

Educators are finding that multimedia holds tremendous promise as a teaching and learning tool in higher education. The latest generation is digital multimedia (using IBM/Intel's Digital Video Interactive or DVI technology), which expands the potential of multimedia by delivering information in digital form that can be more fully integrated into computer-based education and training. This document will help explain the technology behind digital multimedia, and outline some of its specific uses and advantages.

Multimedia

Before explaining digital multimedia, the concept of multimedia should be introduced. Sometimes defined as the convergence of text, graphics, images, sound and full-motion video, multimedia is a "catch all" term for numerous technologies. While the individual technologies will continue to evolve, the resulting visual/textual "collage" already has the ability to attract and hold our attention and to train and/or educate effectively. In addition, the computer's ability to manage a variety of media allows educators to choose what information, examples and simulations best convey the content, with little concern over the original medium of the material. Multimedia tends to be hypertextual, as well. This means that it gives unprecedented control to the user, whether student or lecturer, allowing them to explore topics at will and to navigate through material along paths that more closely address their individual interests.

Most often, our use of multimedia begins as an enhancement to lectures or presentations. In other instances, it can become a tool for self-directed study or a supplement for laboratories. Irrespective of the use, multimedia instruction can be more effective than traditional instruction and delivered in less time and at lower cost. As the reputation for instructional effectiveness of multimedia has grown, the demand for a digital form of multimedia has increased.

The use of analog multimedia, although effective educationally, is limiting in a technical sense because computers can only manipulate digital information. Until recently, most still

images and full-motion video segments were stored on portable media (e.g., VHS tape or laserdisc) and played back from an analog device (e.g., VCR or laserdisc player). This has meant that multimedia computers had to possess the ability to convert analog signals into digital signals that could be edited and stored on the computer. This has also meant that, to employ video in an analog world you had to put up with the inconvenience of an extra box taking up space, more cables, etc. Analog-based multimedia has other limitations, as well:

- Although great progress has been made with computer hardware and software, VCRs and laserdisc players are too large to be efficiently built into computers. On the other hand, CD-ROM drives, which contain only digital information on a smaller disc, are now built into most computers.

- A new laserdisc must be produced to edit and/or update the material, which can be a time consuming and expensive process. This limits the flexibility and affordability of multimedia.

- Perhaps most important, analog-based multimedia has limited communication ability over a computer network, whether a departmental LAN or the Internet. This means that each person who wants to use the images on a laserdisc not only has to have access to the laserdisc, but to a laserdisc player, as well.

Digital Multimedia

Understandably, then, the trend in multimedia is to move from analog forms to digital forms. Essentially, DVI (Digital Video Interactive) transforms and compresses analog information into a stream of ones and zeros -- or digital information -- representing sound and video. To make that transformation possible, DVI combines desktop hardware and software into a package that digitizes, compresses and decompresses video, still images and/or audio. Before detailing the technical aspects of DVI, consider some of the advantages to this digital technology:

- DVI treats multimedia as data files in an all-digital environment.
- DVI video can be assembled with cut-and-paste simplicity.
- DVI is media-independent in the sense that it can use CD-ROMs, LANs, etc.
- DVI can be stored on a network server and made accessible to numerous users.
- Updating segments can be accomplished with ease at any time.
- DVI can take advantage of distribution via CD-ROMs, a smaller and less expensive medium than 12-inch analog laserdiscs.
- DVI will facilitate the expansion of computer-supported collaboration into networking, video e-mail and teleconferencing.
- One DVI device (occupying a single computer slot) can digitize audio, video and stills — previously only accomplished with multiple cards or external devices.

Moving from analog to digital

Theoretically, the advantages of an all-digital environment have been accepted for some time. Actually, the concept of digitizing video is very simple. To explain this digital environment, the

place to begin is with digitizing a single image or frame.

An image is composed of pixels, or picture elements, the smallest dot size of which the picture is composed. To digitize an image, the computer looks at each pixel and assigns it a number corresponding to its color. Of course, a smaller pixel means more pixels per picture and finer detail. Also, using more colors allows for a better reproduction of the picture. However, more pixels and more colors also means that the digitized file becomes larger. It is common to use 24-bit color, which means that there are 16 million possible colors for each pixel, which takes 24 bits (3 bytes) to store the color information for a single pixel. To display a stored image in a digital environment, the computer simply reads the file and sets each pixel on the screen to the color that corresponds to the previously assigned number.

To digitize motion video, a series of images is stored. Standard television video requires 30 frames per second, thus it is necessary to digitize 30 separate still pictures (frames) to make up each second of full-motion video. The dilemma has been file size, both in terms of storing and playing back multimedia. But, before considering video, let's return to a still image. The typical still picture is 320 x 240 pixels, so the image contains 76,800 pixels. If 24-bit color is used, recalling that it takes 3 bytes to store each pixel, it would take 230,400 bytes for a single picture.

Full-motion video requires 30 stills or frames per second. Since each picture or frame is 230,400 bytes, one second of motion video requires 6,912,000 bytes without taking into account the storage required by digitized sound (of course, motion video is normally accompanied by sound). When video clips are used in education, many are 30 seconds long, or longer.

Digitizing 30 seconds of video would pile up more digital information than most computer hard drives can store — enough, in fact, to fill a standard 650 MB CD-ROM. Note that files of this size create playback as well as storage problems. If stored on a CD-ROM, that 30 second video segment would take one to two hours to play back because the CD-ROM data rate (its "playback" rate) is only 150,000 bytes per second. Therefore, simply digitizing video is not enough; it must be compressed.

Compression

It turns out that a lot of the information in video is redundant, that is, some information can actually be thrown away without much degradation in the picture and sound quality. This process is called compression, and is the process that makes digital video feasible on a personal computer.

There are two types of compression: lossy and lossless. The first kind, lossy compression, derives its name because some information is lost in the compression process. When the information is played back (i.e., decompressed), it is not quite the same as the original. For example, if you digitize a picture and throw away every other pixel, the file would be half of its original size. In other words, you have achieved a 50 percent compression ratio. When the picture is reconstituted (the file is decompressed), the computer fills in the missing pixels by interpolating among (similar to averaging) the adjacent pixels. The picture isn't quite as sharp as the original, but probably quite acceptable.

The second type of compression is lossless. As the name implies, no information is lost — only the redundancy is eliminated. For example, consider a picture of the United States flag, particularly the red and white stripes. It takes a lot less space to store the information about each stripe as a rectangle of a specific size, location and color than it does to store the color of each individual pixel in the stripe.

DVI compression is possible because there is redundant information in just about any picture. Digital video uses both lossy and lossless compression to achieve the highest possible compression.

Another type of compression is employed in motion video. In many cases, very little changes in the video from frame to frame. For example, consider video of a waving flag. Unless the video camera is panning the background tends to remain the same. In these cases, the only information stored is the change between frames, not each frame in its entirety.

Various compression methods used together can dramatically reduce the amount of information that is actually stored. For example, DVI technology (as employed in IBM's ActionMedia II adapter) can compress video and sound so one second of video takes only 150,000 bytes. In our earlier example, one second of uncompressed video required 6,912,000 bytes. Thus, compression makes it feasible to play back full-motion video (including sound) from CD-ROM devices.

Uses and advantages

No matter what digital media is chosen (e.g., hard drive, CD-ROM, etc), the content of a multimedia application can now be stored on network servers for shared use by many individuals. This type of storage saves the redundant investment in both players (e.g., laserdisc players) and media (e.g., laserdiscs). It also provides an excellent means of delivering just-in-time training and guidance, as well as internal communications.

An additional benefit of utilizing networks is that they allow the remote updating of multimedia content on local optical devices. Suppose, for example, that a major national accrediting organization stored a multimedia "certification exam" on rewritable optical media at hundreds of sites in the U.S. By using wide area networks, they could add and delete items from that exam, even on a daily basis.

When supported by fast digital networks, ActionMedia II will also allow desk-to-desk videoconferencing. Such conferencing will provide face-to-face interaction between individuals at remote sites, with the simultaneous display of documents or photographic images. Colleagues can even be provided with a "chalkboard" capability for screen annotation and highlighting of information.

Just-in-time guidance — a field traditionally served by reference manuals — can utilize multimedia as well. Students, faculty and alumni are often called upon to perform tasks for which additional information or refresher training is needed. This type of training could be delivered by analog multimedia technology, but would require laserdisc players and a stock of laserdiscs at every location. With ActionMedia II, such instruction can be delivered in full-motion video by accessing a database of short vignettes over a local area network. Delivery of this information can be made very effective by making it sensitive to context and specific to the individuals' needs. In addition, ActionMedia II allows new vignettes to be added and allows old ones to be updated with ease — modifications that are impractical using laserdisc technology.

Many anticipate that multimedia courseware will provide individualized instruction, supplementing lecture and textual formats with a more interesting and engaging multisensory approach to learning. Such multimedia applications will not only provide training on demand but will allow students to become more self-directed. This learning can be supported with media in all forms, from still images to full motion video, and from text to audio. By storing educational content on file servers, institutions will be able to capitalize on affordable networking to serve the needs of many students simultaneously.

Technical Overview

DVI includes:

- a playback card;
- a capture card;
- multimedia files used in applications, such as graphics, video stills, motion video or special effects;
- capture, playback and editing tools from third party developers; and
- software support for DOS, Windows and OS/2.

Note that DVI is operating system independent -- i.e., you can use DVI in a DOS, Windows or OS/2 environment. Also, you could interchange DVI files on an IBM with DVI files on a Mac.

A capture card is required in the personal computer to enable the capture of video (stills or motion). It converts the incoming analog signal into a stream of bytes representing the pixels of the image. If you want to capture motion video in real time, e.g., off a video camera or a VCR, the hardware must be able to compress the information in real time. You have already seen that the computer will not be able to handle the uncompressed data stream. For the highest quality image, the original video should be sent to an off-site facility for digitizing. The cost is approximately $150 per minute of original video.

When it comes to playing back the video file, you can either use a hardware adapter or rely on a software-only solution. A hardware adapter may be preferable because it contains its own processor (it is not dependent on the speed of the PC's processor). All decompression and handling of the video is done by the card itself. This enables you to play back the file at 30 frames per second, which is the same rate used by other video devices, such as laserdisc players and broadcast television. The presence of the card also ensures that video will play back just as well as full screen images as in a small window, and that the video window can be re-sized during playback with no change in the playback rate.

Hardware adapters also can capture motion video so that it can be played back without hardware. If you rely on such a software-only solution, the PC's processor takes care of the decompression of the video file and the process of putting the video up on the screen. An example of software-only playback is IBM's Photomotion. Software-only playback is a trade-off between cost and quality. The processors in today's personal computers are not fast and powerful enough to decompress and display 30 frames per second, or to display videos that fill the screen. You are typically limited to playback at 10 to 15 frames per second into a window of 160 x 120 pixels (a full screen, remember, is normally 640 x 480 pixels). The playback software will skip frames to keep the audio and the video synchronized, so the actual playback rate will depend on the contents of the video and the load on the processor. In other words, you might see a lot less than 10 to 15 frames per second on playback.

Real Time Video and Production Level Video

Compression and decompression algorithms are critical components of DVI; the two types of files created by compression/decompression are Real Time Video (RTV) and Production Level Video (PLV).

RTV files are created by the ActionMedia II card when capturing and compressing full motion video on your computer. Since the ActionMedia II card can only process each frame for 1/30th of a second, the results are not as good as they are with PLV files. This is because the

computer has only 1/30th of a second to compress the file. However, the advantage is that video in RTV file format can be created in real time on your own computer. Quality is still quite good (somewhat less than VHS tape quality), and you can select from a number of trade-offs to control quality for data rate and file size.

PLV video is characterized by both high quality and a low data rate (bytes per second). However, to create a PLV file, you must send a videotape with the desired material to Intel or some other capable service facility for processing. The information on the videotape will be processed off-line by a computer. Because the computer can take as much time as it needs to process the file, optimum compression ratios, at a minimum loss of quality, are obtained. You should have video converted to a PLV file when the video is to be distributed on a standard CD-ROM. Although you could distribute RTV files on a CD-ROM, their data rate is higher than the playback capacity of a CD-ROM.

Frames

By playing 30 frames (or 30 still images) per second, television (and DVI and videodisks and videotapes, etc.) create the illusion of smooth motion. In the movie strip, each frame is a complete picture which can stand by itself. With DVI, as mentioned, some frames can stand by themselves while others are derived from prior frames via compression. A frame that stands by itself -- one that can be decompressed and displayed without reference to any other frame -- is called an intraframe or reference frame. Other frames -- those dependent on a prior frame -- are called interframes, or derived frames, or delta frames. Obviously, the first frame in a file must be an intraframe as there is no prior frame. However, there are occasions when the compression algorithm results in an additional intraframe. For example, the first frame after a scene change. In this case the changes are so extensive that it is simpler just to store the new frame in its entirety.

Recall that DVI employs lossy compression, so that when an intraframe is reconstructed, it is not a perfect copy of the original frame. The information used to recreate the derived or interframes is also not perfect, so that after a number of interframes, the quality of the picture would be unacceptably different from the original. For this reason, every few frames (the actual number depends on several factors), the ActionMedia II card typically will insert an intraframe. (Note: It is possible to create a file without reference frames; this feature is controlled by the software.)

There are both video and audio intraframes. In RTV they are the same frame, but in PLV, a video intraframe is not necessarily the same as an audio intraframe. There is a parameter that determines how often, at a minimum, intraframes are created during compression. This parameter is called the Still Period. If this parameter were set to "one" the computer would make every frame an intraframe. This results in the best quality, but also the highest data rate.

Some other parameters that directly affect the quality (and inversely, the data rate or file size) of the compressed file are "pre-filter" and "quantization." Pre-filtering softens (or blurs) the image slightly before it is compressed, resulting in a file that is about 50 percent smaller than what would be obtained with pre-filtering turned off. Quantization refers to how many blocks the image is divided into when performing compression. Larger sized blocks mean fewer blocks per image, and thus a smaller file size, but the video will have a blocky or poster-like look to it. Some programs set these values themselves, typically offering the user a choice of best, better or good recording quality, while others allow the user more control.

File sizes

Although ActionMedia II is excellent at compressing video, DVI files will still tend to be large. Keep this in mind when planning applications with DVI content. PLV full-motion video will average 150 KB per second, so one minute of video will occupy 9 MB of disk space (including sound). While this is considerably less than the 420 MB or more it would take for the same amount of uncompressed video, it is still not a trivial file size. RTV video might take twice as much space, depending on the quality level chosen. As a result, it is only practical to put very short segments of DVI onto diskettes. Longer segments may be stored on CD-ROMs, read-writable optical disks or on a file server with the intention of delivering information over a network.

Stills

Although the full-motion video capabilities of DVI are excellent, don't ignore its ability to digitize, compress and display still images. For example, many faculty have slide collections. It has not been feasible to transfer these collections to the computer because of the amount of storage they required in digitized format. DVI technology overcomes this obstacle. In fact, DVI can capture and compress images so that several thousand will fit onto a single CD-ROM. A range of compression algorithms are available for stills including industry standards such as JPEG (Joint Photographic Expert Group). As with video, however, many of these options trade quality for file size.

There are several advantages to putting the stills on a CD-ROM, ranging from convenience and space savings to permanency. Because these images are stored in digital format on an optical medium, they will last longer than those stored on magnetic media such as the VHS tape. Images stored on a CD-ROM should last for 50 years. DVI images are also easier to retrieve, organize and duplicate than their slide counterparts. These images may also be incorporated into other software presentations, such as courseware, tutorials or lab exercises. You may even retouch or enhance the pictures with appropriate software.

Remember that the same hardware adapter that handles stills also handles motion video and sound, so you don't need to invest in a collection of single purpose cards.

Working with digital video files

There are some differences between what can be done with DVI files and what can be done with more traditional video sources, such as video from a laserdisc player. Just as with a laserdisc player, DVI files can be played from beginning to end. You can freeze on any frame, and, depending on the software, play the video in slow motion. However, the video cannot be sped up or played backwards.

Recall that compression of DVI files causes its frames to be different than frames on a laserdisc. On a laserdisc, each frame has a complete image, whereas most DVI frames represent only differences in images from the previous frame. The creation of DVI files using intraframes and interframes has some interesting consequences if you are used to laserdiscs. For example, it is not possible to simply "seek" for a specific frame in a DVI file and display that frame or start playing from it. Remember that because interframes are derived from prior frames, accessing them directly would not result in enough information from which to build the screen image. Instead, DVI drivers are written so that when you try to play from an interframe, the driver will

automatically find the closest previous intraframe and start playing from there. Some programs, such as Podium, will actually seek to the nearest previous intraframe, play the file with the video off, and turn on the video when the file reaches the user-specified frame.

CD-ROMs

A CD-ROM is the perfect vehicle for distributing applications and their DVI files, because they have large data storage capacity, and files can be played back at the rate we expect (30 frames per second). CD-ROMs are becoming increasingly popular as more and more titles are published in this medium. There are several organizations that will press CD-ROMs for a reasonable cost. It should cost around $1,000 to create a master CD-ROM, and then a duplication charge of one or two dollars per CD-ROM pressed.

CD-ROMs also provide a form of software copy protection; it is not practical for users to copy the entire contents of the disc. However, you are limited in CD-ROM playback rates to 150 KB per second, which means that only PLV and medium quality RTV are suitable file formats for the medium. PLV is the most reasonable choice for video intended for wide distribution; it costs between $150 to $250 per minute of video to compress the files to this format. You as the author will have to determine your needs in terms of video quality. Must all the video be of high quality? Must it be full screen? Even the lowest quality RTV video looks very good in a smaller window. Where high resolution is needed, will a still image do? There are no data transfer rate restrictions on stills because they are not played back in real time.

The following table gives the approximate capacity of one CD-ROM disc for various types of information. Note that the entries are mutually exclusive — a CD-ROM may not contain 650,000 pages of text plus 5 hours of FM stereo sound.

text	650,000 pages (double spaced)
audio	5 hours of FM stereo or 22 hours of mid-range quality monaural or 44 hours of near AM quality monaural
video stills	5,000 very high resolution or 10,000 high resolution or 40,000 medium resolution (256 x 240)
motion video	72 minutes of full motion video, with sound
mix & match	20 minutes of full motion video with 5,000 high resolution stills with 6 hours of audio over stills with 15,000 pages of text.

In the future, write-once CD-ROM devices are expected to allow for affordable in-house production of CD-ROMs (now they require pressing by an outside vendor). These devices will lower the costs of application production even further, while allowing compatibility with today's low-cost CD-ROM players.

Digital Video Interactive: The ActionMedia II Adapter

Hardware

The IBM ActionMedia II adapter is used to decompress and play back DVI video and audio files. There is also a companion card, the ActionMedia II capture option, which plugs into the ActionMedia II card and enables you to record as well as play back audio and video. The two cards together take up only one slot in a PC. The cards contain a specialized processor which handles the compression/decompression (sometimes referred to as codec) and rendering of the video, thus freeing the PC's processor from that task. The card is capable of playing video at 30 frames per second accompanied by stereo sound. You control the size of the video image and its location on the monitor. You may also change the size and location of the window during playback without disrupting the video.

The ActionMedia II adapter with capture option has the following capabilities:

- to capture, digitize and compress motion video at 30 frames per second. The video may be in NTSC (our television standard), PAL (the European equivalent of NTSC) or RGB format.
- to capture, digitize and compress audio, in mono or stereo, either alone or in conjunction with capturing motion video. Several algorithms for compressing the audio may be chosen.
- to capture, digitize and compress still images. Again, a number of algorithms for compressing the images are available.
- to play back full motion video from a digitized file. The process includes decompressing the digitized video as it is read from the file. A variety of compression algorithms are supported; the correct one will be invoked automatically.
- to play back digitized audio from a file, either in mono or stereo. The process includes decompressing the digitized audio as it is read from the file. Audio might be played back by itself or simultaneously with full motion video contained in the same file. A variety of compression algorithms are supported; the correct one for the particular file will automatically be used.
- to display an image from a compressed file. A variety of compression algorithms are supported with the appropriate one invoked.

Tools and software

Drivers are software programs that directly control the hardware, and provide a simpler software interface that other software (application programs) can use to run the hardware. There are several levels of tools and software that support DVI. The most fundamental level is that of the drivers. The IBM ActionMedia II hardware comes with drivers for OS/2 2.0 and for Windows 3.1. These drivers have two levels of interface: AVK (Audio Visual Kernel) and MCI (Media Control Interface -- a standard multimedia hardware control language defined for Windows and OS/2). The AVK level gives a program complete control over hardware, including the ability to set contrast, tint and brightness, and to control the volume of the left and right audio channels independently, etc. However, one must program in the C or Assembly languages to access the AVK. The MCI level is more accessible, although the function it provides is more limited. Many of the authoring tools that allow you to create programs or presentations using DVI

provide access to MCI, including Multimedia ToolBook, IconAuthor, MEDIAScript for OS/2 (Network Technology Corporation), Microsoft Visual Basic, etc. As of December 1992, it appears that Windows access to DVI should be through Microsoft Video and Microsoft Video Tools.

[Please note that the MCI interface in Windows does not provide capture capability. If you need to capture stills, audio and video under Windows, you will need to purchase capture tools from other third party developers such as Digital Media International of Sunbury, Pennsylvania.]

If you are in the DOS environment you will find that the tools that support DVI include the DVI driver they need. Examples of such tools are IBM's Linkway Live! and MEDIAScript for DOS.

Some tools have DVI functionality built right in. With these tools it is not necessary to write your own MCI commands to the DVI hardware. Examples of these include Podium for OS/2 (University of Delaware), MEDIAScript for OS/2, and Multimedia Desktop (Datalus Incorporated of Okemos, Michigan).

There are some editing tools that allow you to cut and paste clips of DVI motion video, such as Splice (Digital Media International of Sunbury, Pennsylvania) and Jasmine Clipper DVI Editor (Jasmine Multimedia Publishing of Los Angeles, California). Several companies are working on a collection of DVI capture, playback and editing tools (scheduled to become available in early 1993). Jasmine Multimedia Publishing also has the Jasmine Six Pack, a collection of six CD-ROMs featuring clip art video and music that can be incorporated royalty-free into any DVI application. The Jasmine CD-ROMs are also available individually.

There are two very specialized tools that use the ActionMedia II card to capture, assemble and edit high quality video for broadcast purposes. These are D/Vision (TouchVision Systems, Inc. of Chicago, Illinois) and Montage (Montage Group, Ltd. of New York City).

Even though DVI is a relatively new technology, McGraw-Hill has already published a CD-ROM titled "The Multimedia Encyclopedia of Mammalian Biology." This CD-ROM uses the IBM ActionMedia II card to play back video clips of mammalian behavior.

Conclusions

Digital video represents a significant advance in the state of the art of multimedia. For the first time authors are able to combine stills, motion video and sound, in an all-digital format using a single technology. The multimedia files are no different than other data or program files, so they can be stored, transmitted and processed in a similar manner.

The IBM ActionMedia II adapter uses DVI technology to deliver full motion video, windowed or full screen, stills and stereo sound, thus it represents a complete multimedia solution. The adapter can also be used to capture motion video, stills and audio. It can play back video from a digital file, or directly from an analog laserdisc or videotape player.

With this technology it is possible to deliver exciting, useful and instructive applications all on a CD-ROM, providing an unmatched combination of quality, affordability and portability.

Glossary

ActionMedia II	The product name of the IBM/Intel cards utilizing DVI technology.
DVI	Digital Video Interactive, the Intel name for the technology used to compress and decompress the video and audio signals.
Interframe	A compressed video or audio frame that contains information on the differences between this frame and the previous frame. As such, it does not in itself contain sufficient information to recreate the frame.
Intraframe	A compressed video or audio frame that in itself contains enough information to completely recreate the video or audio information.
JPEG	Joint Photographic Experts Group, an international standard for compression and decompression of still images.
NTSC	National Television Standards Committee, the name of the video broadcast standard used in the United States.
PAL	Phase Alternate Line, the name of the video broadcast standard used in Western Europe.
PLV	Production Level Video, a file format containing video and audio which can be played back using the ActionMedia II cards. PLV video is created off-line at a processing facility.
RGB	Red Green Blue, a standard for a video signal in which there are three separate components, the red, green and blue color signals.
RTV	Real Time Video, a file format containing video and audio which can be created on a personal computer using the ActionMedia II cards. There are several versions of the RTV format, the latest being RTV 2.1. The current ActionMedia II hardware and drivers can play back any version of RTV.

About the authors

Edwin J. Pinheiro received his bachelor's degree in electrical engineering from Case Western Reserve University. He joined IBM's Rochester Development Lab in 1974, and has worked with universities on the development of computer based instructional materials since 1984. Pinheiro has been awarded six United States patents.

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About the Institute for Academic Technology

The IAT is a national institute working to place higher education at the forefront of academic technology development and implementation. A partnership between the University of North Carolina at Chapel Hill and the IBM Corporation, the IAT strives to facilitate widespread use of effective and affordable technologies in higher education. To that end, the IAT conducts a number of briefings, workshops and planning sessions to keep academics informed about available technologies and to help explore the use of technology on individual campuses. For more information, contact:

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